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## AN ANALYSIS OF SEED AND SEEDLING LOSSES AT MT. SOPRIS TREE NURSERY

1976

# Rocky Mountain Region

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# AN ANALYSIS OF SEED AND SEEDLING LOSSES AT MT. SOPRIS TREE NURSERY

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## INTRODUCTION

Production of coniferous tree seedlings has been eratic in recent years at Mt. Sopris Tree Nursery which is operated by the USDA, Forest Service near Carbondale, Colorado. Irregular seedbed densities and high cull rates at lifting time indicate that seedling losses have occurred but the cause and timing of these losses have been difficult to ascertain. Several destructive agents including birds, fungi, weather, residual pesticides and soil problems have been suggested as possible causes for these losses but these subjective observations have not been supported by data.

At the request of the nurseryman, Mr. R. W. Ellis,[1/] a study was initiated to document causes of seed and seedling losses during the 1976 growing season.

## STUDY METHODS AND SAMPLING SCHEDULE

The overall objective of this study was to monitor randomly established plots located within nursery seedbeds sown during the spring of 1976 and to identify and quantify losses suffered during the subsequent growing season.

To minimize possible genetic variation, one typical seed source was selected by the nurseryman for each of the three principal tree species grown at Mt. Sopris Nursery:

| Tree Species | Seed Lot | Seed Origin | Percent Germination |
|---|---|---|---|
| Ponderosa pine (*Pinus ponderosa* Laws.) | 21 - 75 | San Juan N. F. | ? |
| Lodgepole pine (*P. contorta* var. *latifolia* Engelm.) | 4 - 70 | Routt N. F. | 70 |
| Engelmann spruce (*Picea engelmannii* Parry) | 21 - 64 | Rio Grande N. F. | 42 |

1/ Mr. Ellis was recently replaced by John R. Scholtes

A portion of each seed lot was marked with a red fluorescent dye to facilitate recovery from the soil (1).

The marked and unmarked seed were sown in alternative rows in seedbeds in two different blocks of the nursery. Block 8 was chosen because of its good production record and Block 5 was selected as a poor production area. Ten study plots were established in the experimental seedbeds of Block 8 and ten within Block 5. The first 25 feet of each seedbed were eliminated from consideration to avoid border effect. All plots were marked with colored flag stakes for easy relocation.

The sampling unit used in the study was a circular plot encompassing two seed rows within the seedbed, one marked and one unmarked. A diagram of the sampling unit and its placement is provided in Appendix A. Within the plot two one-foot sections of seed row were delimited. The row section within the marked seed row was the "destructive sample" which was excavated after seedling germination to determine actual sowing density and associated pre-emergence losses. The other one-foot section was a "monitoring sample" which was inventoried throughout the season for post-emergence losses. Soil samples were also collected within the study plots to monitor populations of pathogenic soil fungi.

The study plots were established during the end of May 1976 and soil samples taken to measure initial populations of soil pathogens. Four soil cores were collected with a 6-inch probe from within the plot and placed in a labeled paper bag. All samples were immediately stored in an ice chest for transporation to the laboratory.

Soil samples were assayed for the two principal seedling pathogens known to be a problem at the nursery, *Pythium* spp. and *Fusarium* spp.. The soil was processed and cultured on petri dishes of selective media which are formulated to restrict the growth of other soil fungi. These techniques were modified from those used in agricultural pathology (2, 3). Counts were made of the fungal colonies per culture dish and these values converted to standard units. This sampling and analytical procedure was repeated at monthly intervals throughout the growing season.

Seedling emergence began the first week in June and continued through the month. Towards the end of the emergence period an extensive damage survey was conducted to inventory the losses caused by bird predation and post-emergence damping-off. The sampling scheme consisted of laying a 100 foot cloth tape along a seed row starting at a randomly selected point. Emerged seedlings and types of damage were then recorded at 10 one-foot sections regularly spaced along the tape. This procedure was repeated three times for each tree species in each of the two nursery blocks.

Seedling emergence was completed by the first week in July and the one-foot "destructive samples" were excavated to recover the marked tree seed and determine pre-emergence losses. The one-lineal-foot sections were dug up and the marked seeds removed, counted and stored under refrigeration. These seeds were cultured for fungal pathogens as were any diseased seedlings found on the plots.

Inventories of seedlings were made on the "monitoring sample" row sections at regular intervals throughout the growing season. The numbers of live seedlings within the one-foot sections were recorded along with any observable losses. The last inventory was taken on September 30 and the final monthly soil sample collected on October 3 when the growing season was effectively finished.

## RESULTS AND DISCUSSION

Seedling losses at Mt. Sopris Tree Nursery varied between tree species, nursery location and time during the 1976 growing season (Table 1). Engelmann spruce and ponderosa pine suffered the greatest total loss, almost 94% of the seeds sown. Lodgepole pine losses averaged 60% but were quite variable between the two nursery blocks. Block 5 had higher losses than Block 8, which corresponds to earlier nursery production records; Block 8 has consistently produced better tree seedlings especially the more sensitive lodgepole pine.

The timing of the nursery losses is also of interest; over 75% of the potential seedlings were lost within the first 6 weeks after sowing (Figure 1). Most mortality occurred around the time of seedling emergence, although lodgepole pine losses continued into midsummer. Another slight increase in seedling loss was noted during late summer.

The heavy losses suffered during seedling germination and emergence could have been caused by a number of factors. Pre-emergence losses are extremely difficult to diagnose because they may result from non-viable seed, pathogenic soil organisms or a combination of both.

Poor seed germination can result from low quality seed, poor seed handling or suboptimal sowing practices. Low seed viability, especially for Engelmann spruce (42%) was probably partially responsible for these early season losses. Germination tests were lacking for the ponderosa pine seed lot. Accurate, recent seed germination data are essential for developing sowing rates.

The relatively high seed sowing densities in this study (Table 1) may have been detrimental because high densities of poor quality seed can stimulate pathogens within the soil. Pathogenic fungi

TABLE 1 Seed and Seedling Attrition at Mt. Sopris Nursery during 1976 Growing Season

| Tree Spp. | Nursery Block | No. Seeds Sown [1] 5/25 | % Loss [2] | No. Emerged Seedlings [1] 6/14 | % Loss [2] | No. Surviving Seedlings [1] 6/25 | % Loss [2] | 7/9 | % Loss [2] | 8/19 | % Loss [2] | 9/30 | Total % Loss [2] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Engelmann spruce | 8 | 119.8 ± 9.8 | 74.5 | 30.6 ± 9.0 | 5.0 | 24.6 ± 7.7 | 2.5 | 21.6 ± 6.5 | 7.8 | 12.2 ± 3.2 | 0.3 | 11.8 ± 2.7 | 90.2 |
| | 5 | 105.8 ± 21.8 | 77.2 | 24.2 ± 4.8 | 7.0 | 16.8 ± 3.7 | 8.7 | 7.6 ± 2.9 | 3.4 | 4.0 ± 2.1 | 0.4 | 3.6 ± 1.7 | 96.6 |
| | Total | 112.8 ± 11.5 | 75.7 | 27.4 ± 4.9 | 5.9 | 20.7 ± 4.2 | 5.4 | 14.6 ± 4.1 | 5.8 | 8.1 ± 2.3 | 0.4 | 7.7 ± 2.0 | 93.2 |
| Lodgepole pine | 8 | 46.8 ± 5.2 | 27.4 | 34.0 ± 4.0 | 20.5 | 24.4 ± 4.0 | + 0.3 | 25.8 ± 5.5 | 7.3 | 22.4 ± 3.2 | 1.3 | 21.8 ± 3.4 | 53.4 |
| | 5 | 25.0 ± 2.5 | 46.4 | 13.4 ± 3.6 | 17.6 | 9.0 ± 2.6 | 0.8 | 8.8 ± 3.0 | 5.6 | 7.4 ± 2.5 | 0.8 | 7.2 ± 2.3 | 71.2 |
| | Total | 35.9 ± 4.5 | 34.0 | 23.7 ± 4.2 | 19.5 | 16.7 ± 3.4 | + 1.7 | 17.3 ± 4.1 | 6.7 | 14.9 ± 3.1 | 1.1 | 14.5 ± 3.1 | 59.6 |
| Ponderosa pine | 8 | 82.6 ± 5.5 | 86.0 | 11.6 ± 1.5 | 1.5 | 10.4 ± 1.4 | 2.2 | 8.6 ± 1.6 | 1.7 | 7.2 ± 1.6 | 0.7 | 6.6 ± 1.5 | 92.0 |
| | 5 | 70.4 ± 11.2 | 86.6 | 9.4 ± 2.8 | 9.3 | 5.0 ± 1.1 | 0.8 | 4.4 ± 0.7 | 1.7 | 3.2 ± 0.4 | 0.6 | 2.8 ± 0.5 | 96.0 |
| | Total | 76.5 ± 6.2 | 86.3 | 10.5 ± 1.6 | 3.7 | 7.7 ± 1.2 | 1.6 | 6.5 ± 1.1 | 1.7 | 5.2 ± 1.0 | 0.6 | 4.7 ± 1.0 | 93.8 |

[1] Figures presented as average ( ± one standard error) per lineal foot of seed row

[2] Loss based on total seeds sown

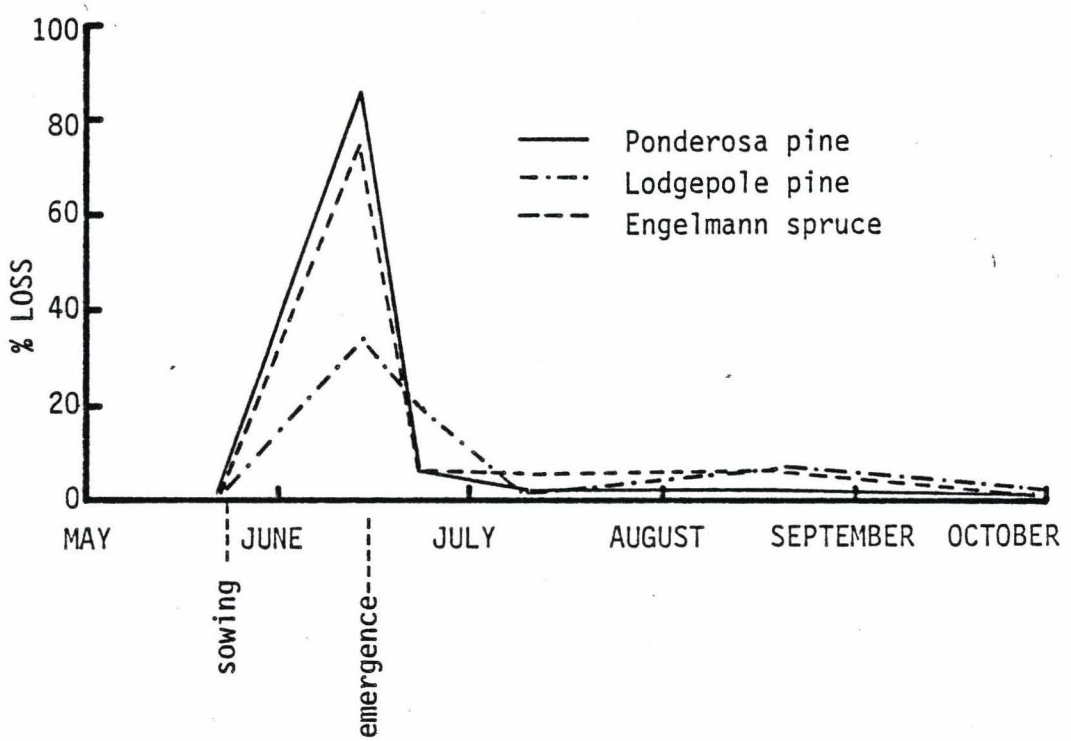


Figure 1 - The majority of losses at Mt. Sopris Tree Nursery occurred around the time of seedling emergence.

often attack weak or slow germinating seedlings. High seed densities provide an abundant food base for pathogens and lead to weaker seedlings because of overcrowding. Fungal isolations from excavated seed produced both pathogenic fungal species, *Pythium* and *Fusarium*.

Seedling losses that occurred after emergence were easier to identify than pre-emergence losses. Two major types of damage were noted during the extensive survey: post-emergence damping-off losses (Figure 2) and bird damage (Figure 3).

Damping-off losses averaged around 25% of emerged seedlings for all three conifer species (Table 2). Apparently, all species of seedlings were equally susceptible to these fungi. Actual losses were extremely variable, however, and ranged from 0 to as high as 80%. By contrast, a similar study at the USDA, Forest Service Wind River Nursery reported only 19% loss to pathogenic fungi during the first growing season (4). Damping-off was most severe in wet areas. Both *Pythium* and *Fusarium* were recovered from diseased seedlings. Damping-off losses decreased as soon as the seedlings developed secondary thickening of the hypocotyl.

Population levels of pathogenic soil fungi showed considerable variation between fungal species, location in the nursery and time (Figure 4) but attempts to relate these trends to actual seedling loss were unsuccessful. Monthly soil populations of *Pythium* and *Fusarium* did not correlate with periods of pathogenic loss. Although *Pythium* levels were highest at the time of seedling emergence they remained at substantial levels throughout the growing season and *Fusarium* levels peaked during the late summer (Fig. 4) when seedling losses were inconsequential. Apparently other complicating factors are involved or a more sensitive sampling technique should be developed before future correlations are attempted.

Bird damage was more severe in seedbeds of ponderosa pine and lodgepole pine (Table 2) than Engelmann spruce which may relate to seed size. The larger pine seeds are more easily located by the birds and provide more food. Two kinds of damage were observed on damaged seedlings (Fig. 3). The most critical type of injury involved complete decapitation and subsequent death of the newly emerged seedling. Damage was less severe when the birds merely clipped off the ends of the cotyledons. Clipped seedlings sometimes recovered because their apical meristems remained unharmed, although damping-off fungi often claimed weakened individuals. Birds appeared to be attracted to the strip of sand covering the seed rows and were seen feeding along the rows. Due to this feeding behavior and their tendency to flock, bird damage was usually aggregated. Bird damage was brief in duration, being limited to the period of seed exposure; once seedlings shed their seed coats, bird activity ceased entirely.

Figure 2 - Damping-off losses as high as 80% and averaging around 25% were suffered early in the growing season.

Figure 3 - Two types of bird injury were observed on newly emerged pine seedlings. Completely decapitated seedlings died although some seedlings with minor foliage clipping survived.

TABLE 2 Seedling losses caused by birds and pathogenic fungi at Mt. Sopris Tree Nursery, 1976.

| Tree Spp. | Nursery Block | Percent Loss Birds Average | Range | Percent Loss Damping Off Average | Range | Percent Loss Total |
|---|---|---|---|---|---|---|
| Engelmann spruce | 8 | 0.4 | 0 - 8 | 27.6 | 6 - 72 | 28.0 |
| | 5 | 3.0 | 0 - 15 | 23.4 | 0 - 63 | 26.4 |
| Lodgepole pine | 8 | 8.3 | 0 - 32 | 24.9 | 6 - 62 | 33.2 |
| | 5 | 17.8 | 0 - 67 | 25.2 | 0 - 75 | 43.0 |
| Ponderosa pine | 8 | 8.3 | 0 - 30 | 15.4 | 0 - 80 | 23.6 |
| | 5 | 24.1 | 0 - 75 | 23.6 | 0 - 50 | 47.7 |

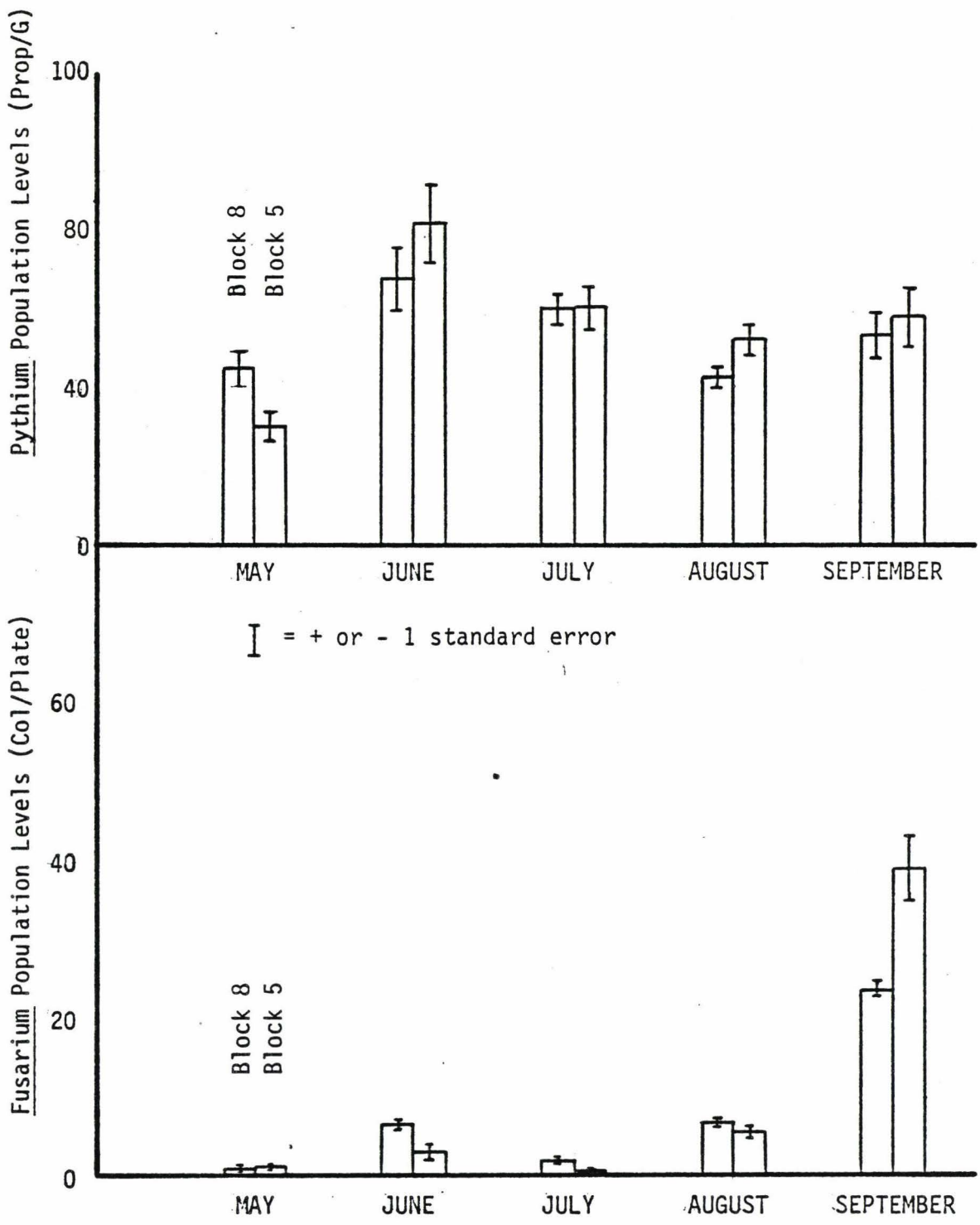


FIGURE 4 - POPULATION LEVELS OF TWO PATHOGENIC FUNGI VARIED BY THE FUNGAL SPECIES, NURSERY BLOCK AND MONTH OF SAMPLING.

## CONCLUSIONS AND RECOMMENDATIONS

The majority of seed and seedling losses occurred early in the growing season during the period from sowing to seedling secondary thickening. Although exact causes of injury were difficult to identify prior to seedling emergence, poor seed quality, high populations of pathogenic soil fungi and bird predation were found to be serious problems during the post-emergence period. Attempts to correlate pathogenic losses to monthly soil fungi population levels were unsuccessful.

Several management alternatives could be employed to curtail the high rate of seedling attrition early in the growing season:

1. Poor seed quality - All tree seed should be tested for germinability prior to sowing. Seed lots with germination percentages below an established nursery standard should be discarded. Sowing rates must consider seed quality; oversowing to compensate for poor quality seed will only lead to other problems. A positive effort should be made to improve seed collection and processing procedures to assure maximum seed quality. Seed treatment such as moist stratification may stimulate germinability.

2. Pathogenic soil fungi - Disease organisms including *Pythium* spp. and *Fusarium* spp. exist at high population levels in nursery soil. Several control alternatives should be considered.

2.1 - Seeds can be treated with a protective fungicide but this practice has been found to adversely affect germination percentage and seedling vigor.

2.2 - Seedbeds could be treated with a fungicidal chemical immediately before or after sowing to depress pathogenic fungal activity during seedling emergence. This alternative should be rated second priority because of erratic results and the high cost of treatment.

2.3 - All potential seedbeds should be fumigated with a volatile gas such as methyl bromide-chloropicrin to eliminate disease organisms prior to sowing. Fall fumigation would be necessary at Mt. Sopris Nursery because of the cool, wet soil conditions in the Spring. Weed control would be an additional benefit of fumigation. Negative aspects include the high cost of treatment and suppression of desirable soil microorganisms. Soil fumigation should be regarded as a drastic measure because of its nonselective biocidal properties and should only be used when extreme measures are warranted.

3. Bird predation - These losses are especially annoying because they affect seedlings that have already emerged and lead to poor stocking levels because of their erratic occurrence. Two alternatives exist.

3.1 - Bird dispersal devices are available which purport to frighten away potential predators. The success of these operations are usually proportional to the monetary investment and labor expended. The immediate proximity of private residences to the seedbeds at Mt. Sopris Nursery may be restrictive.

3.2 - Seed treatment with bird repellent chemicals has proven effective in other nurseries. Arasan is a widely used bird repellent that may justify testing; this chemical has additional benefits as a fungicide.

## EPILOGUE

Nursery management made a decision to fumigate 25 acres of projected seedbed during the fall of 1976 because of serious weed problems. This treatment proved to be very successful in eliminating weed seeds in the soil and also depressing pathogenic soil fungal levels and is covered in Biological Evaluation R2-76-15.

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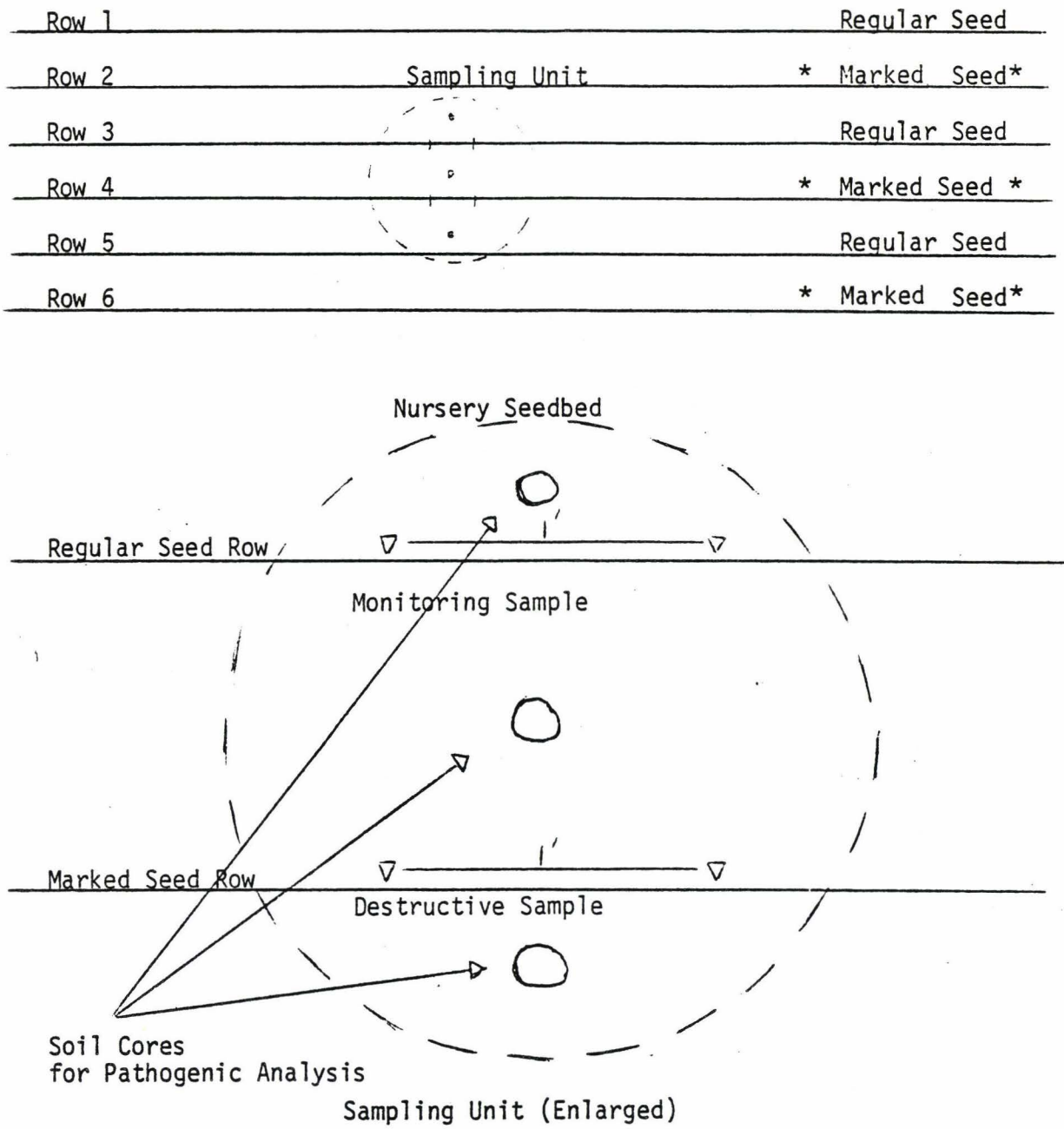


APPENDIX A - DESIGN AND LOCATION OF SAMPLING UNITS WITHIN THE NURSERY BED AT MT. SOPRIS TREE NURSERY.